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Towards Commercializing the "Made in Sri Lanka" Lithium-Ion Batteries

Natural vein graphite found in Sri Lanka has tremendous potential in LIB applications due to the high purity and excellent electrochemical properties, which can translate to better battery performance and thereby more cost-effective energy storage.

Energy plays a crucial role in the human civilization. Today, the whole world is facing an energy crisis with the rising energy demand, fluctuating prices, supply constraints, and environmental concerns. While renewable energy resources can alleviate some of the global energy security challenges, their intermittency and non-dispatchability can cause problems. Therefore, robust energy storage systems (ESSs) are also important in the sustainable energy transition. Among the many ESS technologies, battery energy storage system (BESS) is one of the most popular methods, as they can be easily adapted to distributed applications and quickly deployed. The Lithium-ion battery (LIB) has significant benefits over other batteries. They have a longer life cycle, higher energy density, faster charge and discharge cycles, quick manufacturing and deploying processes, and lower maintenance requirements. LIB technology is one of the best candidates for a BESS, and its market share and R&D efforts are growing fast [1], [2]. Over the last 30 years, the LIB has come a long way with various improvements to make it more compact and safe while simultaneously enhancing the energy density and cycle life.

Producing LIB electrodes with Sri Lankan graphite

Previous studies in this area demonstrated that the LIB performance varies with cell chemistry. The active materials play a vital role in the characteristics of LIBs. The search for new cathode and anode materials with advanced properties is driven by the needs to improve the battery performance and thus reduce the costs of energy storage. A research team from the Department of Mechanical Engineering (DoME) of the University of Moratuwa (UoM) is working to produce a commerciable LIB that consists of an anode made from Sri Lankan graphite, and is compatible with prevailing cathode and electrolyte materials. Furthermore, they intend to perform thermal analysis and modeling, which is extremely crucial for the safety of the battery and the user. The project conducted in collaboration with the National Center for Advanced Battery Research (NCABR) at the National Institute of Fundamental Studies (NIFS) Kandy and the Uwa Wellassa University (UWU), involves both experimentation and computational modelling.

Figure 1: Research facilities at NIFS Kandy

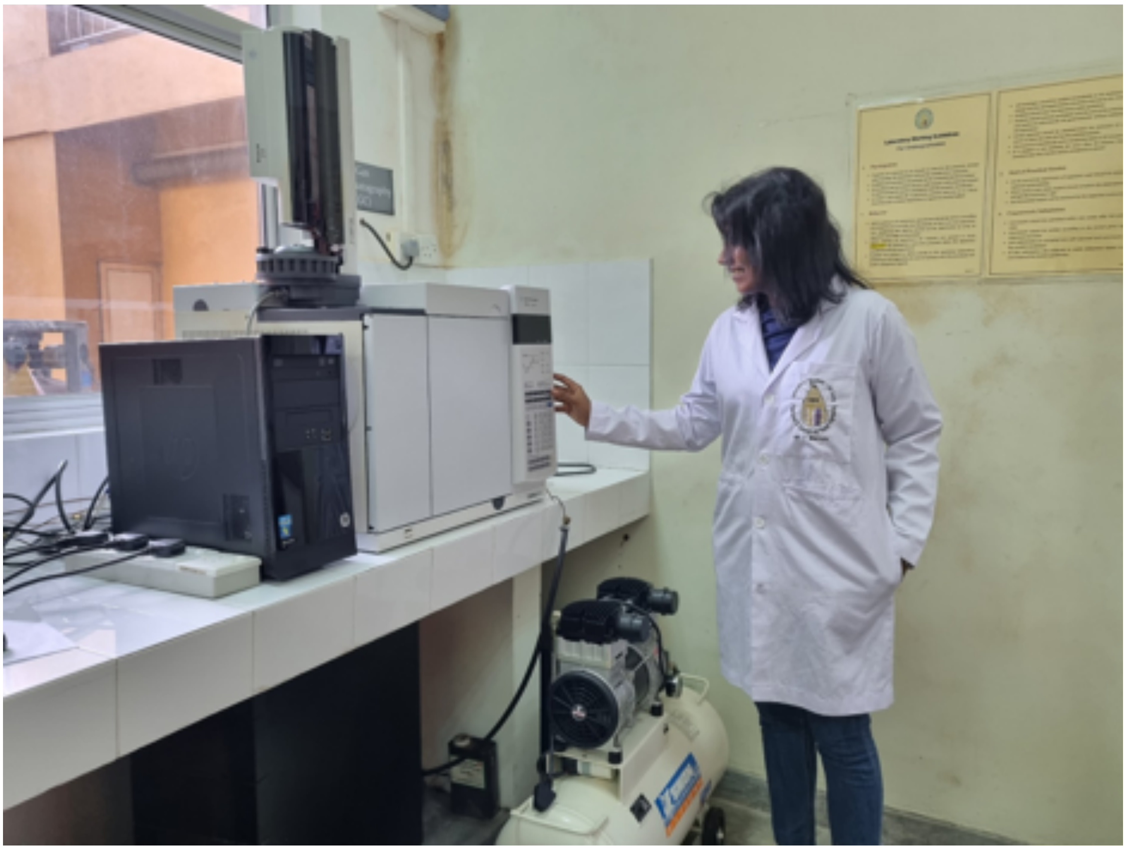

Figure 2: Performing laboratory work at UOM

Uniqueness of Sri Lankan vein graphite

Currently, the synthetic graphite and porous carbon used in commercial LIB applications are relatively expensive. The natural vein graphite found in Sri Lanka is high in crystallinity and purity, and yet is not often used in electrochemical systems. There are four structural vein graphite types, each with 95 – 99 % carbon in its composition. The impurities in them are either intercalated within adjoining layers of graphene or attached to the surface of the graphite mechanically. Various chemical and thermal purification methods have been found to remove and upgrade them to 99.99 % carbon content [3]. Natural vein graphite found in Sri Lanka has tremendous potential in LIB applications due to the high purity and excellent electrochemical properties, which can translate to better battery performance and thereby more cost-effective energy storage. Therefore, it is beneficial to investigate the possibility of developing an anode material for LIB with the locally available vein graphite using an eco-friendly and economically viable approach.

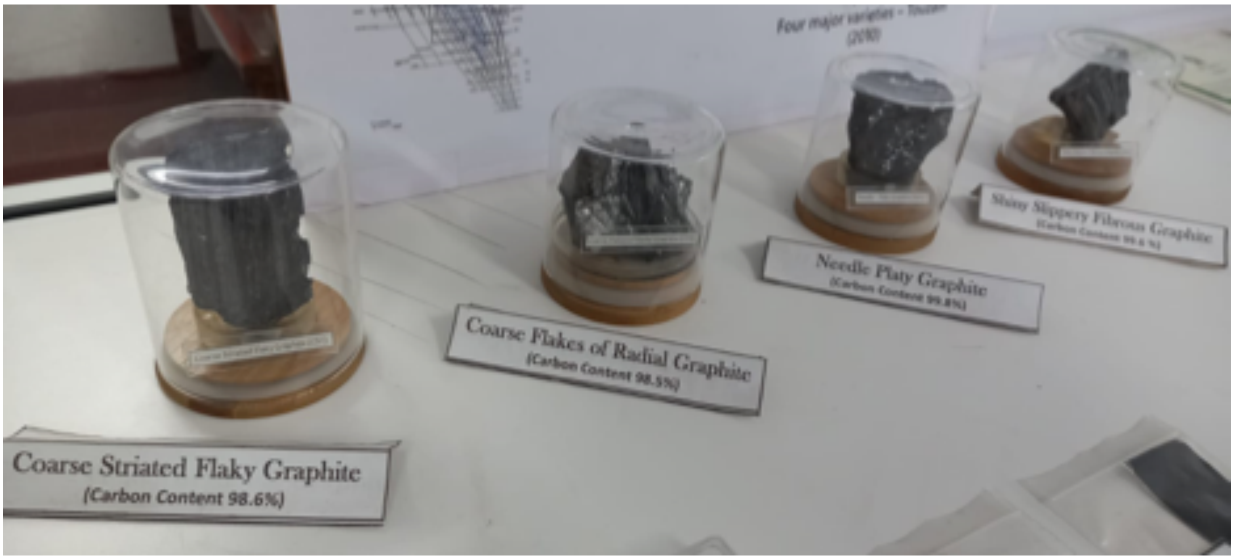

Figure 3: Types of Sri Lankan vein graphite

Potential for commercialisation

With the rising penetration of electric vehicles (EV), reducing the cost of batteries has become more important than ever, in order to ensure the long-term sustainability of EVs. With the competing goals of cost and performance, it is a challenge to determine the best battery configuration and cell chemistry. The effect of the electrode coating thickness too plays a vital role in the economic decisions. Thus, the preliminary work carried out by the DoME research team focused on investigating the impact of increasing the positive electrode coating thickness (μm) of LIBs on the cell cost ($/kWh) and the battery performances in mass production, considering different cell types as case studies [4].

“With the rising penetration of electric vehicles (EV), reducing the cost of batteries has become more important than ever, in order to ensure the long-term sustainability of EVs.”

This study considered five battery types based on their cell chemistries. Keeping graphite as the common anode, cathode materials such as NMC811, NCA, LFP, LMO, and 50%/50% NMC532/LMO were selected for this analysis. The positive electrode coating thicknesses were varied from 60 µm to 120 µm. And the analyses were carried out on the cell cost (Fig. 3), volumetric energy density (Fig. 4), and the gravimetric energy density (Fig. 5) for each cell.

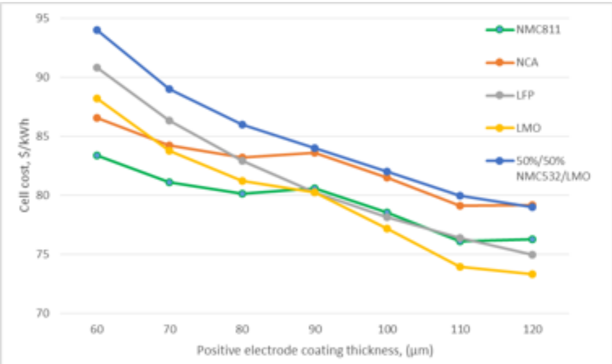

Figure 4: Cell cost comparison for five positive electrode materials under variable electrode coating thickness

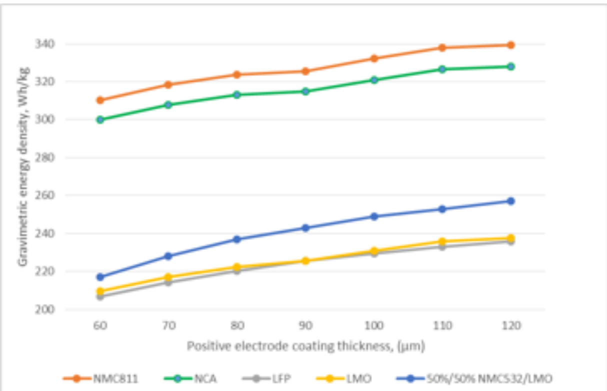

Figure 5: The volumetric energy density comparison for five positive electrode materials under variable electrode coating thickness

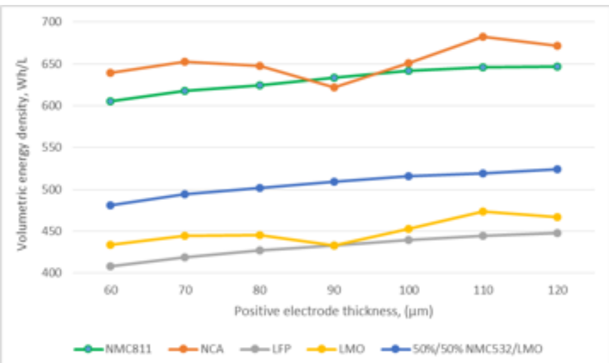

Figure 6: The gravimetric energy density comparison for five positive electrode materials under variable electrode coating thickness

It was observed that the cell cost per kWh decreases and the cell-specific energy increases with the positive electrode coating thickness until 120 µm, regardless of the cell type. While the cost of positive active material increases with positive electrode coating thickness, limiting the non-active components and enhanced performance leads overall material cost reductions. Therefore, this analysis can be applied to determine the optimum positive electrode thickness for each cell type based on the cost and cell performance.

Future prospects

Natural vein graphite found in Sri Lanka has tremendous potential in LIB applications due to the high purity and excellent electrochemical properties. While using this as the anode material, it is crucial to find the most suitable combination of a cathode, an electrolyte, and separator materials to achieve the best capacities and thermal stability of the cells. DoME UoM, together with the NIFS and UWU are addressing these aspects in an ambitious drive to locally develop a LIB at commercially viable scale. Such a product will add value to Sri Lankan raw materials, help to capture global markets, bring in much-needed foreign exchange, while ensuring the country's energy security, job creation, and industrial development.

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